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PHYSICS.—*Thermoelectric measurement of cutting tool temperatures.*[1] HENRY SHORE. Massachusetts Institute of Technology (Communicated by MAYO D. HERSEY).

A knowledge of the temperatures developed under the chip in the process of cutting metal is of importance for all research problems in metal cutting, especially those relating to the properties of the lubricants employed. Comparatively little has been attempted in this field, although calorimetric methods for observing the heat imparted to the chips have been used in lathe work[2] and thermocouples inserted close to the cutting surface have been used in drilling tests.[3]

The method adopted in the present experiments was suggested by Dr. Lyman J. Briggs of the Bureau of Standards. This method consists in utilizing the contact point between tool and work as the hot junction of a thermoelectric circuit. This is entirely feasible since tool steel is of different composition from machine steel and hence, for a difference in temperature at the junctions, a thermal e.m.f. is produced, which depends on the temperature difference between the two junctions.

Before attempting any calibrations, a preliminary run was made to see if the pressure produced at the top of the tool would affect the

[1] Published by permission of the Department of Electrical Engineering, Massachusetts Institute of Technology. The experiments were conducted under the supervision of Prof. V. Bush. The problem was brought to the writer's attention by Prof. M. D. Hersey in connection with the work of the Special Research Committee on the Cutting and Forming of Metals, American Society of Mechanical Engineers. See Mech. Eng. **46**: 20-30, 57, 1924.

[2] Brackenbury, H. I. and Meyer, G. M., *Heat generated in the process of cutting metal.* Engineering **91**: 39-40. 1911.

[3] Schwartz, H. A. and Flagle, W. W., *Significance of tool temperatures.* Proc. Amer. Soc. Test. Mat. **23**[1]: 27-39. 1923.

e.m.f. generated. This was accomplished by placing the work in a lathe and bringing the tool to bear on it. An electric soldering iron with a fine tip was placed at the point of contact, and the resultant deflection of the millivoltmeter read. A light cut was then taken and the lathe stopped, leaving the tool in position. The work was suddenly made to bear down hard on the tool by pulling on the belt by hand, while the hot soldering iron remained at the point of contact, its temperature being held constant. The resulting deflection was the same as before, so it was concluded that pressure did not appreciably change the thermal e.m.f. This was important, since it meant that only an ordinary calibration of the tool and work metals would be necessary.

TABLE 1.—CALIBRATION DATA FOR TOOL AND WORK METALS (TOOL METAL—JESSUP HIGH SPEED STEEL)

WORK METAL—ORDINARY CAST BRASS		WORK METAL—MILD STEEL	
Thermal e.m.f.	Temperature diff.	Thermal e.m.f.	Temperature diff.
millivolts	*degs. C.*	*millivolts*	*degs. C.*
0.36	43	0.04	43
0.50	55	0.05	58
0.65	68	0.07	97
0.80	79	0.10	136
0.85	84	0.13	146
0.90	87	0.16	175
0.95	93	0.32	209
1.00	96	0.40	228
1.17	110	0.51	242
1.30	123	1.00	315
1.50	140	1.84	400

The calibration of the metals was accomplished by placing a bar of the tool metal (16 inches long by $\frac{3}{16}$ inch square) and a rod of work metal (16 inches long by $\frac{1}{4}$ inch in diameter) in a small graphite crucible (No. 00) with 400 grams of pure tin. The crucible was heated electrically by inserting three lugs on the periphery of the crucible, spaced 120° apart, and connecting each lug to one phase of a 5-k.w., 3-phase, 60-cycle generator. The line current was regulated by adjusting the generator field rheostat, which varied the impressed voltage. This method of melting the tin enabled the heat input to be easily and quickly fixed and at the same time to be held constant. A constant heat input was necessary to allow thermal equilibrium to be reached at the inserted ends of the two metals undergoing calibration. The temperature of the tin was measured

by an alumel-copper thermocouple when calibrating the steel rod, and with a high temperature mercury thermometer when calibrating the brass. Data for this calibration are given in Table 1.

The next step was the actual determination of the e.m.f.'s produced for varying rates of removal of chips in a lathe. It was not feasible to insulate the tool without a special tool holder, so the work was insulated instead. The ends of the work were drilled and tapped for a $\frac{3}{8}$ inch, 16-thread screw. Hard rubber plugs $\frac{1}{2}$ inch long were inserted in these holes and filed flush with the ends of the work metal, then drilled and countersunk to fit the lathe centers. The dog was insulated from the lathe by wrapping varnished cambric around the tail. While the work was effectively insulated, the use of hard rubber center plugs at the ends limited to depth of cut, for due to bearing friction the plugs deteriorated rapidly, and threw the work off center. The thermoelectric circuit, starting at the point of contact of tool and work, was completed through work, commutator,

TABLE 2.—TEMPERATURE RISE WHEN CUTTING CAST BRASS. (CUTTING SPEED, 16.0 FEET PER MINUTE; AVERAGE INITIAL DIAMETER, 0.52 INCH)

RATE OF REMOVING CHIPS	E.M.F.	TEMPERATURE RISE
lb. per minute	*millivolts*	*degs. C.*
0.0024	0.35	42
0.0036	0.50	55
0.0062	0.55	59
0.0086	0.60	64
0.0181	0.77	78
0.0476	1.10	106

TABLE 3.—TEMPERATURE RISE WHEN CUTTING MILD STEEL (CUTTING SPEED, 13.5 FEET PER MINUTE; AVERAGE INITIAL DIAMETER, 0.88 INCH)

RATE OF REMOVAL OF CHIPS PER MINUTE	E.M.F. CORRECTED	TEMPERATURE RISE
lb. per minute	*millivolts*	*degs. C.*
0.0010	0.08	112
0.0036	0.17	165
0.0020	0.30	205
0.0030	0.45	237
0.0121	0.65	270
0.0300	0.65	270
0.0208	0.67	273
0.0235	0.72	279
0.0297	0.72	279
0.0321	0.77	285
0.0177	0.80	290
0.0270	0.82	292

millivoltmeter, and tool. One lead of the millivoltmeter was soldered to the free end of the tool, while the other went to a wooden container of mercury held in a ring stand. An annular copper disk, wetted previously with mercury, dipped into the container. The disk was held onto the work by means of a bakelite boss, but kept in good contact with the work by a copper strip placed under the set-screw of the dog. Using this arrangement, no parasitic or extraneous e.m.f.'s could be detected.

To measure the generated e.m.f., it was only necessary to take a cut and note the reading of the millivoltmeter. This reading was sensibly constant for any particular cut, 5 per cent being the maximum deviation which occurred whenever a chip broke off from the work.

The data obtained for cutting brass and mild steel without the use of cutting fluids are given in Tables 2 and 3. These were reduced to usable form by means of the calibration curves, and by calipering the work before and after each run.

Final results, also given in Tables 2 and 3, show at first a rapid increase of temperature with increasing rates of cutting the metal, but dropping to a more gradual rise at faster cutting rates—about 100 deg. C. rise for brass at $\frac{1}{10}$ pound per minute, and about 300 deg. C. for mild steel at $\frac{1}{10}$ pound per minute.

It is hoped that these experiments may later be continued in order to collect systematic information on the effect of varying the cutting speeds and depth of cut, as well as the tool and work materials and cutting fluids. A more complete paper, which will include the dimensional analysis of these and other published data, is in preparation by M. D. Hersey and the author.

SPECTROSCOPY.—*Regularities in the arc spectrum of nickel.* FRANCIS M. WALTERS, JR., Bureau of Metallurgical Research, The Carnegie Institute of Technology (Communicated by W. F. MEGGERS).

More than two years ago I collected all available spectroscopic data for iron, cobalt, and nickel, constructed complete wave-number tables for the arc spectra of these elements, and began to investigate the structure of these spectra. Results for iron[1] and for cobalt[2] have already been published; the present note gives some preliminary results for the arc spectrum of nickel.

[1] WALTERS. This JOURNAL **13**: 243. 1923. J. O. S. A. & R. S. I. **8**: 245. 1924.
[2] WALTERS. This JOURNAL **14**: 407. 1924.

One of the questions attacked in these investigations was whether or not the *alternation law* of spectroscopy is obeyed throughout a triad of elements in column VIII of the periodic table. The spectrum of neutral iron was found to consist mainly of terms whose maximum multiplicities are odd (3, 5, and 7 fold); the structure of the cobalt-arc spectrum appears to be due to terms of even multiplicities (2 and 4), while odd values (1 and 3) appear again to characterise the arc spectrum of nickel.

Although the latter spectrum is the simplest of the three, it has been the most difficult to analyse, and it is still in a somewhat incomplete and unsatisfactory state. After finding a considerable number of relative terms, and assigning inner quantum numbers to them, attempts were made to identify the terms which belong together in a polyfold group. Inner quantum numbers were given on the basis of combinational properties of the terms, and the spectral types of some of these terms were suggested by the Zeeman effects for nickel lines.

The way in which a combination of two polyfold terms gives rise to a multiplet may be illustrated by the following group of six lines, an example of a three-fold P term combining with a three-fold D term, the individual levels of each triple level being distinguished by subscripts which represent the inner quantum numbers. The lines are represented by their wave numbers in vacuo and by their intensities and character as given by Hamm.[3] All of these lines belong to class II of King's[4] temperature classification of the nickel lines. The separations of the polyfold terms are given in italics.

	73958.40		73283.41		72450.11
	D_3		D_2		D_1
45593.97	28364.39	*674.95*	27689.44	*833.28*	26856.16
P_2	10 R, II		8 u, II		6, II
			931.38		*931.49*
44662.49			28620.82	*833.17*	27787.65
P_1			10 R, II		7 R, II
					691.51
43971.00					28479.16
P_0					7 R, II

The Zeeman effects for the above six lines as observed by Graftdijk[5] are given for comparison with the patterns calculated from Landé's[6] scheme.

[3] HAMM. Zeitschr. wiss. Phot. **13**: 105. 1913.
[4] KING. Astroph. Journ. **42**: 344. 1915.
[5] GRAFTDIJK. Arch. Neerl. III A: 192. 1912.
[6] LANDÉ. Zeitschr. für Physik **15**: 190. 1923.

Terms	*Observed*	*Calculated*
D_1P_0	(0.00) 0.69	(0.00) 0.50
D_1P_1	(0.84) 0.53, 1.55	(1.00) 0.50, 1.50
D_1P_2	(0.00) 2.63	(**0.00**, 1.00) 0.50, 1.50, **2.50**
D_2P_1	(0.00) 1.20	(**0.00**, 0.33) 0.83, 1.17, **1.50**
D_2P_2	(0.59) 1.40	(0.33, **0.67**) 0.83, **1.17**, **1.50**, 1.83
D_2P_3	(?) 1.33	(**0.00**, 0.17, 0.33) **1.00**, 1.17, 1.33, 1.50, 1.67

Considering that fairly large errors may be present in the observed values, it appears that the Zeeman effects for nickel may be expected to be in quantitative agreement with the values derived from Landé's outline for multiplets of the first stage. Unfortunately, the published data on magnetic resolution of nickel lines are insufficient for the purpose of identifying many spectral terms.

In addition to the D and P terms already mentioned, it is possible that 71946.69, 72831.10, and 74163.21 may represent a low lying F level, a higher one being represented by 40552.34, 41050.93, and 41189.82. The terms 39754.70, 40000.00, 40662.44 and 43250.41, 43543.84, 44494.29 are probably of the type D, while 58145.92, 58429.10, 58553.42 have the appearance of a P level. In nearly all of these cases the interval rule is violated, but such violations are known to be common in complex spectra. In some of the combinations the intensity rule also appears to be violated, and on account of the fairly general validity of this rule the above term groupings will be regarded as provisional. Further investigation of the Zeeman effect for nickel lines is now in progress, and it is hoped that these new data will permit unambiguous identification of all the terms. For the present I am content to give in Table 1 the relative terms, inner quantum numbers (in parenthesis), and the wave numbers and description of the observed spectral lines arising from combinations of these terms. The distribution of the inner quantum numbers indicates that the spectrum consists of singlets and triplets; there appear to be no quintets unless the term separations are very large. In this connection it is observed that the terms fall into five (or more) rather definite groups as follows: 70753 to 74163, 58146 to 60641, 37563 to 47497, 29900 to 31557, and 21965 to 25077.

The number of nickel lines classified in Table 1 is 345. These include nearly all of the stronger lines of the spectrum of neutral nickel. Of the lines of classes I and II there remain unclassified only 19 lines; of the remaining lines (intensity > 2) there remain 21 lines of temperature class III, 9 of class IV, 43 of class V, and 58 for which no temperature classification is given.

TABLE 1.—Relative Terms and Combinations in the Arc Spectrum of Nickel.

	74163.21 (4)	73958.40 (3)	73283.41 (2)	72831.10 (3)	72450.11 (1)
47497.11 (4)	26665.94 4–I	26461.22 4–I			
46748.30 (2)				26082.76 3–I	25701.85 5–II
46095.10 (4)	28068.10 4–II	27863.32 5–II		26735.91 4–I	
45621.22 (3)	28542.05 4–I			27209.79 7–I–II	
45593.97 (2)		28364.39 10R–II	27689.48 8u–II	27237.08 5–II	26856.16 6–II
45585.14 (3)		28373 25 3–II	27698.25 5–II	27245.92 4–II	
45150.00 (1)			28133.39 4–I		27300.21 3–I
45078.76 (3)	29084.45 6R–II	28879.65 10R–II		27752.33 5–II	
44842.44 (3)	29320.75 5–II	29115.94 9R–II	28440.94 9R–II	27988.58 7R–II	
44682.27 (4)	29480.94 7R–II	29276.18 10R–II		28148.83 4–I	
44662.49 (1)			28620.82 10R–II		27787.65 7R–II
44494.29 (3)	29668.83 10R–II	29464.07 10R–II	28789.12 7R–II	28336.67 5–II	
44330.45 (3)		29627.92 4R–II	28952.98 6R–II	28500.63 4–I	
44274.80 (2)		29683.67 2–II	29008.65 10R–II	28556.34 6–II	
44000.13 (1, 2)		29958.32 1–I	29283.27 3R–II	28830.96 5–II	28449.93 5–II

TABLE 1.—*Continued*

	74163.21 (4)	73958.40 (3)	73283.41 (2)	72831.10 (3)	72450.11 (1)
43971.00 (0)					28479.16 7R–II
43771.25 (1)			29512.13 1–I		28678.88 5–II
43543.84 (2)		30414.59 4–II	29739.61 5R–II	29287.27 5R–II	28906.30 10R–II
43250.41 (1)			30032.98 1–I		29199.72 8R–II
43132.21 (3)	31030.96 4R–II	30826.18 8R–I	30151.20 7R–II	29698.86 5R–II	
42721.60 (2)		31236.77 2–II	30561.81 4–II	30109.50 5R–II	29728.54 2–I
42377.10 (3)	31786.16 1–I	31581.35 1–I	30906.29 5R–II	30454.00 3–II	
41189.82 (4)	32973.48 3–II	32768.50 10R–II		31641.28 1–II	
41180.98 (1)			32102.44 6–II		31269.13 4–II
41050.93 (3)	33112.28 5–II	32907.50 9R–II	32232.49 8R–II	31780.19 4–II	
40662.44 (3)	33500.87 4–II	33296.00 10R–II	32620.97 6–II	32168.67 2–I	
40552.34 (2)		33406.01 6–II	32731.06 8R–II	32278.73 5–II	31897.82 10R–II
40000.00 (2)		33958.39 6	33283.41 9R–II	32831.08 4–II	32450.14 6–II
39754.70 (1)			33528.71 6–II		32695.42 10R–II
38524.10 (3)	35639.11 3	35434.30 4		34306.92 2	
37562.45 (2)		36395.98 4	35720.98 4	35268.63 3	34887.62 5

TABLE 1.—*Continued.*

	71946.69 (2)	70753.30 (2)	60641.83 (2)	59434.38 (0)	58553.42 (2)	58429.10 (1)	58145.92 (0)
47497.11 (4)							
46748.30 (2)		24004.96 3–IIA					
46095.10 (4)							
45621.22 (3)		25132.16 3–V ?					
45593.97 (2)	26352.74 6–I	25159.34 7–II	15047.78 6–I		12959.43 8–IA	12835.18 6–IIIA	
45585.14 (3)	26361.60 4–I	25168.16 4–I			12968.20 1		
45150.00 (1)	26796.71 3–I						
45078.76 (3)					13474.69 2		
44842.44 (3)	27104.25 4–II	25910.93 10–II	15799.41 5–II?		13711.21 8–IIIA		
44682.27 (4)							
44662.49 (1)	27284.18 5–II	26090.79 6–II	15979.33 7–I	14771.79 10–I	13890.72 7–IIIA	13766.63 8–IIIA	13483.43 6–IIIA
44494.29 (3)	27452.43 2 I	26259.05 8–II	16147.50 6–I		14058.88 6–IIIA		
44330.45 (3)		26422.93 8–II	16311.40 3				
44274.80 (2)	27672.03 7–II	26478.63 9–II	16367.08 7–II		14278.61 4–V ?	14154.30 4	
44000.13 (1, 2)		26753.22 7–II	16641.78 3–II				14145.63 2

TABLE 1.—*Continued.*

	71946.69 (2)	70753.30 (2)	60641.83 (2)	59434.38 (0)	58553.42 (2)	58429.10 (1)	58145.92 (0)
43971.00 (0)						14458.18 7-II	
43771.25 (1)	28175.38 5-II						
43543.84 (2)	28402.81 5-II	27209.79 7-I-II	17098.04 3				
43250.41 (1)	28696.31 6R-II	27502.95 3-I	17391.48 3-II	16183.93 3	15302.94 3	15178.79 5-II	
43132.21 (3)	28814.52 5-II	27621.11 10R-II	17509.65 6-I		15421.13 7-V ?		
42721.60 (2)	29225.08 2-I	28031.72 10R-II	17920.32 5-I		15831.78 10-II	15707.57 1	
42377.10 (3)	29569.59 4R-II	28376.22 1-I					
41189.82 (4)							
41180.98 (1)	30765.69 2-I	29572.28 10R-II	19460.83 8-I	18253.41 10-I	17372.42 5-II		16964.94 9-II
41050.93 (3)	30895.73 1-I	29702.38 4R-II	19590.92 4		17502.50 6-II		
40662.44 (3)	31284.25 2-II	30090.86 5-II	19979.44 2		17891.01 5-I		
40552.34 (2)	31394.33 4-II	30201.04 2-I	20089.50 2		18001.07 4-IV ?	17876.94 7-II	
40000.00 (2)	31946.72 3-I	30753.30 3-II	20641.94 2			18429.25 4-II	
39754.70 (1)	32191.97 5-II	30998.54 5R-II	20887.22 2	19679.64 3			18391.22 6-II
38524.10 (3)	33422.77 3-II	32229.17 8R-II	22117.75 4-II				
37562.45 (2)	34384.21 3	33190.82 9R-II	23079.50 6-II		20990.97 2-IIA		

TABLE 1.—*Continued*

	31557.37 (2, 3)	31373.28 (2)	30051.13 (1)	29900.75 (2)	25077.36 (4)	24988.47 (3)
47497.11 (4)					22420.04 9–III	
46748.30 (2)		15375.05 1u				
46095.10 (4)	14537.71 3–IV				21017.87 7–III	
45621.22 (3)					20543.86 7–III	
45593.97 (2)	14036.53 10–IV–V	14220.63 5–V		15693.29 4		
45585.14 (3)	14027.82 2	14211.90 4			20507.94 2	
45150.00 (1)						
45078.76 (3)	13521.37 10–III				20001.44 4–III	20090.33 1u
44842.44 (3)	13285.07 8–III	13469.14 9–III				19854.04 10–III
44682.27 (4)	13124.89 10–III				19604.87 7u–V	
44662.49 (1)		13289.16 8–III	14611.38 6–V	14761.74 9–V		
44494.29 (3)	12936.95 10–IV	13121.07 9–III				19506.07 6–IV
44330.45 (3)	12773.04 4	12957.13 7				19342.00 6–III
44274.80 (2)	12717.36 4	12901.44 10–V		14373.99 5–V		
44000.13 (1, 2)	12442.83 1	12626.84 7	13948.93 4			
43971.00 (0)			13919.74 9–V			

TABLE 1.—*Continued*

	31557.37 (2, 3)	31373.28 (2)	30051.13 (1)	29900.75 (2)	25077.36 (4)	24988.47 (3)
43771.24 (1)			13720.06 2			
43543.84 (3)			13492.75 9–IV	13643.12 4		
43250.41 (1)		11877.15 2	13199.27 7–V	13349.74 2		
43132.21 (2)	11574.85 2	11758.97 2		13231.45 9–III		18143.81 5–IV
42721.60 (2)		11348.32 3	12670.50 3	12820.24 8–V		
42377.10 (3)		11003.96 1		12476.43 2		
41189.82 (4)					16112.54 3–V	
41180.98 (1)				11280.27 4		
41050.93 (3)				11150.23 2	15973.56 4–V	16062.49 6–V
40662.44 (3)					15585.05 5	15673.96 7–IV?
40552.34 (2)			10501.33 2			

	24891.76 (3)	24849.40 (2, 3)	24830.52 (4)	24385.74 (3)	23816.82 (2)	23697.14 (4)
47497.11 (4)			22666.85 5u–III	23111.67 4		
46748.30 (2)				22362.69 8–III	22931.53 6–V	
46095.10 (4)				21709.51 9–III		22398.07 3
45621.22 (3)						21924.02 3

TABLE 1.—*Continued*

	24891 76 (3)	24849.40 (2, 3)	24830.52 (4)	24385.74 (3)	23816.82 (2)	23697.14 (4)
45593.97 (2)	20702.29 7–III					
45585.14 (3)	20693.09 5–III				21768.40 7–III	21888.11 1
45150.00 (1)					21333.26 5–III	
45078.76 (3)			20248.23 4u–III	20693.08 5–III		
44842.44 (3)	19950.66 3u	19993.08 5–III		20456.77 3	21025.63 3–V	
44682.27 (4)			19851.69 3u	20296.51 3–III		20985.12 4–III
44662.49 (1)						
44494.29 (3)	19602.49 7u-V	19644.89 2	19663.83 7u–III			20797.24 4–III
44330.45 (3)		19481.05 3–V		19944.69 4–III	20513.64 5–III	
44274.80 (2)		19425.36 7–V				
44000.13 (1, 2)				19614.34 4-V	20183.21 3–V	
43971.00 (0)						
43771.25 (1)					19954.33 2	20074.05 8–III
43543.84 (2)						
43250.41 (1)						
43132.21 (3)		18282.70 2	18301.63 4–V			

TABLE 1.—*Continued*

	24891.76 (3)	24849.40 (2, 3)	24830.52 (4)	24385.74 (3)	23816.82 (2)	23697.14 (4)
42721.60 (2)		17872.27 6–III				
42377.10 (3)						
41189.82 (4)			16359.33 4u–V			17492.69
41180.98 (1)						
41150.93 (3)	16159.16 6–V	16201.55 3	16220.39 5u–V			17353.77 4–IV
40662.44 (3)	15770.60 10–III	15813.06 3				
40552.34 (2)		15703.18 7–IV		16166.59		
40000.00 (2)		15150.57 4–IV				
39754.70 (1)					15937.81 1	
38524.10 (3)	13632.17 1					
37562.45 (2)		12713.16 5				

	23409.10 (1)	23331.22 (2, 3)	23328.95 (1)	22857.20 (2)	22122.70 (2)	21965.83 (3)
47497.11 (4)						
46748.30 (2)				23891.18 4		
46095.10 (4)						
45621.22 (3)						

TABLE 1.—*Continued*

	23409.10 (1)	23331.22 (2, 3)	23328.95 (1)	22857.20 (2)	22122.70 (2)	21965.83 (3)
45593.97 (2)	22184.94 1	22262.86 3				23628.15 3–V
45585.14 (3)				22728.00 2		
45150.00 (1)						
45078.76 (3)						23112.92 3–V
44842.44 (3)				21985.27 4–V		22876.59 3
44682.27 (4)				21825.07 3		22716.42 3–V
44662.49 (1)						
44494.29 (3)						22528.51 4–V
44330.45 (3)					22207.66 1	
44274.80 (2)				21417.58 3–V	22152.00 3	
44000.13 (1, 2)						
43971.00 (0)			20641.94 2			
43771.25 (1)						
43543.84 (2)		20212.60 3	20214.89 2u	20686.59 3-V	21421.12 3–III	
43250.41 (1)	19841.32 4		19921.51 3u–IV		21127.74 4–IV?	

TABLE 1.—*Continued*

	23409.10 (1)	23331.22 (2, 3)	23328.95 (1)	22857.20 (2)	22122.70 (2)	21965.83 (3)
43132.21 (3)		19801.01 4–V		20274.96 1		
42721.60 (2)	19312.48 5–V	19390.39 8–V	19392.64 4u–V	19864.25 1u		
42377.10 (3)				19519.71 3	20254.30 4–IV	
41189.82 (4)						
41180.98 (1)	17771.97 7–V					
41050.93 (3)				18193.65 3–V		
40662.44 (3)				17805.21 6–V	18539.61 2	
40552.34 (2)	17143.23 5r–V	17221.15 7–V		17695.24 4–V		
40000.00 (2)		16668.78 2u–V	16671.04 3u–V		17877.27 1	
39754.70 (1)	16345.61 8–V		16425.74 8r–V		17632.00 3	
38524.10 (3)		15192.96 2u				
37562.45 (2)	14153.36 2	14231.45 8–V	14233.35 1			

BOTANY.—*New plants from Central America*—II.[1] PAUL C. STANDLEY, U. S. National Museum.

The species here described as new are mostly plants of the Canal Zone, which have been studied during the preparation of a flora of that region. There are included also descriptions of two Costa Rican plants, and of a new cactus from the Republic of Salvador.

Inga gracilipes Standl., sp. nov.

Tree 6 m. high, the young branchlets sparsely puberulent but soon glabrate; petioles 1.5–3 cm. long, glabrous, narrowly winged above, bearing at the middle and at the apex a sessile cup-shaped gland; rachis 1.5–2 cm. long, with a cup-shaped gland at apex, narrowly winged, the wing attenuate below, the rachis 4 mm. wide at apex; leaflets 2 pairs, elliptic-oblong, 6–11 cm. long, 2.5–4.5 cm. wide, abruptly and shortly obtuse-acuminate, obtuse at base, coriaceous, glabrous, lustrous above, with prominent venation; flowers umbellate, the umbels paniculate, the peduncles very slender, 2.5–4.5 cm. long, solitary or fasciculate, obscurely puberulent or glabrate; pedicels filiform, 8–10 mm. long, minutely and very sparsely puberulent; calyx tubular, 3 mm. long, sparsely and very minutely puberulent; corolla greenish white, narrow-funnelform, 8–9 mm. long, glabrous; stamen tube short-exserted; very young fruit oblong, strongly compressed, with scarcely thickened margins, glabrous, acute at base, subsessile.

Type in the U. S. National Herbarium, no. 1,219,236, collected on brushy slope between France Field, Canal Zone, and Catival, Province of Colón, Panama, near sea level, January 9, 1924, by Paul C. Standley (no. 30353).

The vernacular name is "guava," a term applied locally to all species of *Inga*. *Inga gracilipes* belongs to the section *Leptinga*, characterized by pedicellate flowers, but in its nearly glabrous flowers it is distinct from the other Central American species of the group. It is, however, closely related to some of the Brazilian species, although it appears to differ from each of them in one or more details.

Anaxagorea panamensis Standl., sp. nov.

Slender shrub 1–2 m. high, the branchlets sparsely ferruginous-puberulent when young but soon glabrate; petioles 3–5 mm. long, glabrate; leaf blades lance-oblong, 9–16 cm. long, 2.5–4 cm. wide, acuminate, obtuse or acutish at base, thin, deep green and lustrous above, glabrous, beneath paler, when very young puberulent along the costa, but elsewhere glabrous, the lateral nerves 6 or 7 pairs, diverging at a wide angle, arcuately anastomosing remote from the margin; flowers axillary, solitary, the pedicels 2.5 cm. long, very slender, obscurely puberulent or glabrous, with a minute bractlet near the base; sepals ovate-acuminate, 8 mm. long, ferruginous-puberulent, thin; outer petals pale dull yellow, linear-oblong, obtuse, 2 cm. long, thin, puberulent, the inner petals scarcely 1 cm. long, triangular-ovate, acuminate; follicles numerous, bronze-green, glabrous, the stipe 1–1.5 cm. long, the body about 1 cm. long, apiculate, splitting along one side at maturity and exposing the lustrous seed.

[1] Published by permission of the Secretary of the Smithsonian Institution.

Type in the U. S. National Herbarium, nos. 1,216,855–6, collected in wet forest along the Río Tapia, Province of Panama, Panama, near sea level, Dec. 7, 1923, by Paul C. Standley (no. 26168). The following collections are of the same species:

PANAMA: Río Tapia, *Standley* 28247, 28289, 30660. Hills north of Frijoles, Canal Zone, *Standley* 27589.

One other species, *A. crassipetala* Hemsl., has been described from Central America (Nicaragua), but according to the description it is not closely related to the present plant. The Panama species is related to *A. acuminata* St. Hil., of South America, which has coriaceous leaves with very different venation.

Annona hayesii Safford, sp. nov.

Large shrub or small tree, the young branchlets ferruginous-tomentose at first but soon glabrate; petioles 3–7 mm. long; leaf blades elliptic-obovate or oblong-obovate, 12–25 cm. long, 5–9 cm. wide, abruptly acuminate, obtuse or rounded at base, thin, deep green above, paler beneath, when young sparsely and minutely sericeous with brownish hairs but soon glabrate; pedicels 10–15 mm. long, solitary or fasciculate in the leaf axils, brown-tomentose, bearing a small ovate bract below the middle; calyx lobes triangular, acute, 2.5 mm. long, tomentose; outer petals linear, dilated at base, about 3 cm. long, obtuse, densely brown-tomentose, the inner petals minute; fruit subglobose, 5 cm. long or more, smooth, with scant pulp and thin skin; seeds smooth, brown, lustrous, compressed, 1 cm. long.

Type in the U. S. National Herbarium, no. 717078, collected near Yaviza, southern Darién, Panama, April, 1914, by H. Pittier (no. 6592). The following additional collections are referred here:

PANAMA: La Palma, southern Darién, *Pittier* 6598. Matías Hernández, Province of Panama, *Pittier* 6749. Corozal Farm, Canal Zone. *Pittier* 6684. Road to Corozal, *Bro. Gervais* 141. Old Las Cruces Trail, between Fort Clayton and Corozal, *Standley* 29179. Tumba Muerto Road, near Panama, *Standley* 29723. Punta Paitilla, Province of Panama, *Standley* 26272. Near Juan Franco Race Track, Province of Panama, *Standley* 27704.

Annona hayesii is related to *A. reticulata*, a species distinguishable at a glance by its uniformly narrow leaves.

Unonopsis pittieri Safford, sp. nov.

Medium-sized tree with pyramidal crown, the branchlets at first minutely sericeous but soon glabrate; petioles 4–6 mm. long; leaf blades oblong-elliptic or elliptic-oblong, 14–32 cm. long, 5.5–8.5 cm. wide, abruptly acuminate, obtuse and slightly unequal at base, thin, concolorous or nearly so, minutely sericeous beneath along the costa, elsewhere glabrous; flowers greenish, borne in few-flowered racemes on old wood, the pedicels 2 cm. long, minutely sericeous, with a minute bractlet near the middle; calyx shallowly trilobate, minutely sericeous, the lobes obtuse; petals rounded-elliptic, very thick and fleshy, sparsely and minutely sericeous outside, strongly concave, the outer ones 8 mm. long, the inner slightly shorter.

Type in the U. S. National Herbarium, no. 716051, collected along the Río Fató, Province of Colón, Panama, altitude 100 meters or less, July, 1911, by H. Pittier (no. 3871).

Here probably belongs a fruiting specimen, *Maxon* 6890, from the Río

Chinilla, Canal Zone. The berries are globose, 1.5 cm. in diameter, glabrous, red at maturity, and long-stipitate. The single globose seed is deeply pitted.

Pittier states that the vernacular name is "yaya," and that the soft wood is used for building purposes. The genus is a South American one, and no species has been known previously from North America. Species from Central America formerly placed in *Unonopsis* are now referred to *Desmopsis*.

Trichilia unifoliola Blake & Standl., sp. nov.

Shrub or small tree 3–6 m. high; branchlets nearly or quite glabrous; leaves alternate, 1-foliolate, very rarely 3-foliolate; petioles flattened and hispidulous above, 1–3.3 cm. long; leaflet sessile or obscurely petiolulate, oval or oblong-oval, sometimes slightly obovate-oblong, 4–12 cm. long, 2.2–5.5 cm. wide, obtuse or retuse, often with short blunt apiculation (2.5 mm. long or less), cuneate to rounded and usually unequal at base, usually firm, deep green and somewhat shining above, glabrous on both sides except for the often barbatulate cups in the axils of the veins beneath, prominulous-reticulate on both sides, the principal veins 6–8 pairs, whitish and prominent beneath; panicles axillary and terminating the branchlets, subsessile, about 1 cm. long and thick, 3-fid, densely flowered; flowers sessile; calyx 2 mm. long, glabrous, the teeth 5, very short, obtuse, obscurely ciliolate; petals 5, free, oblong, 3.8 mm. long, obtuse, glabrous; stamens 10, 3.8 mm. long, the filaments alternately unequal, connate for nearly half their length into a glabrous tube, the free portions hirsute on margin and inside, cuspidate-bifid at apex, the anthers glabrous; ovary densely strigose, inserted in a fleshy, crenately 10-lobed disk about half its length, 3-celled; style glabrous, thick, about equaling ovary, the stigma small; capsule subglobose, warty, short-pilose, 7 mm. thick, brownish, 3-seeded.

PANAMA: Sabana de Juan Corso, near Chepo, Oct. 1911, *H. Pittier* 4755 (type no. 679918, U. S. Nat. Herb.). Near Punta Paitilla, *Piper* 5426; *Standley* 26314, 30810. Bella Vista, *Standley* 25333. Near Matías Hernández, *Standley* 28881. Between Matías Hernandez and Juan Díaz, *Standley* 31989. Near big swamp east of Río Tecumen, *Standley* 26685.

All the specimens cited are from the Province of Panama, where the plant is common in thickets. The species seems clearly to be a derivative of *Trichilia trifolia* L., agreeing with it in flowering and fruiting characters, but differing in its almost always solitary leaflet, much larger than those of *T. trifolia* and of different outline. Two of the specimens examined show on the flowering branchlets one or two small leaves that bear a single lobe on one side at the base of the leaflet, or occasionally a single small lateral leaflet, rarely a third abortive one. *Trichilia trifolia* has a rather wide range in America, from Mexico to Venezuela and the islands off the Venezuelan coast, but it is not known in Panama, where it appears to be entirely replaced by *T. unifoliola*.

Bernardia macrophylla Standl., sp. nov.

Erect shrub 1.5–2.5 meters high; branchlets densely covered with very short ascending hairs; petioles 3–10 mm. long; leaf blades oblanceolate-oblong or oblong-obovate, 11–19 cm. long, 3.5–8.5 cm. wide, acute or acu-

minate, cuneately narrowed to the base, penninerved, crenate-serrate, copiously pilose on both surfaces with short simple hairs, the lateral nerves about 12 on each side; staminate spikes axillary, 3–4 cm. long, much interrupted, the rachis hirtellous with ascending hairs, the bracts broadly ovate, many-flowered; pistillate spikes terminal, many-flowered, about 2.5 cm. long, the flowers sessile; capsule 5 mm. long, covered with minute appressed hairs.

Type in the U. S. National Herbarium, no. 1,218,687, collected in moist thicket near the Río Tecumen, Province of Panama, Panama, near sea level, Jan. 3, 1924, by Paul C. Standley (no. 29389). Nos. 29380 and 29471 from the same locality belong to this species.

The nearest relative of the Panama plant is *B. corensis* (Jacq.) Muell. Arg., in which the leaves are relatively broader, mostly obtuse, coarsely crenate, and with few lateral nerves.

Opuntia salvadorensis Britt. & Rose, sp. nov.

Plant 8–10 cm. high, much branched and spreading; joints flattened, orbicular to short-oblong, 10–15 cm. long, glabrous; areoles rather few, 1.5–3 cm. apart, small, circular, bearing tawny felt; spines usually 1 to 3, very unequal, slender-acicular, the longest ones up to 6 cm. long, white or becoming tawny; flowers yellow; petals about 2 cm. long; ovary about 2.5 cm. long, obovoid, bearing small areoles without spines; fruit not seen.

Type in the U. S. National Herbarium, no. 1,207,015, collected by Dr. Salvador Calerón at the Hacienda La Concordia, Departamento de Usulután, El Salvador, January 19, 1924 (no. 2100).

No species of *Opuntia* has heretofore been reported from El Salvador, although it is quite possible that there may be several native species. We should refer this species to the series *Tunae* as limited in our monograph of the cactaceae. It is probably to be placed nearest *O. triacantha* and *O. antillana*, two West Indian species.

Tontanea glabra (Bartl.) Standl.

Coccocipsilum glabrum DC. Prodr. **4**: 397. 1830.

This species, described from Panama from specimens collected presumably by Née over a century ago, has not been found again until recently. It was collected near Fort Lorenzo, Canal Zone, March, 1923, by C. V. Piper (no. 5983).

Evea guapilensis Standl., sp. nov.

Stem suffrutescent, simple, terete, about 25 cm. high, green, glabrous, the internodes 2–5 cm. long, stipules green, persistent, 1 cm. long or more, bilobate, the lobes linear from a narrowly triangular base; petioles slender, 3–4 cm. long; leaf blades elliptic, 14–21 cm. long, 6.5–9.5 cm. wide, abruptly short-acuminate at each end, thin, deep green and glabrous above, paler beneath, sparsely hirtellous along the nerves; flower head terminal, solitary, subsessile, 2 cm. in diameter, the bracts purplish green, rounded and apiculate at apex, densely furnished on both surfaces with soft slender multicellular appressed hairs.

Type in the U. S. National Herbarium, no. 1,153,029, collected in wet forest near Guápiles, Province of Limón, Costa Rica, altitude about 500 meters, March 12–13, 1924, by Paul C. Standley (no. 37025).

Evea nana Standl., sp. nov.

Stems suffrutescent, simple, 15 cm. high, subterete, green, glabrous, the internodes 1–2 cm. long; stipules green, persistent, glabrous, about 6 mm. long, bilobate, the lobes oblong-linear; petioles slender, 3.5 cm. long; leaf blades oblong-elliptic, 15–16 cm. long, 6 cm. wide, acuminate at each end, thin, glabrous, deep green above, paler beneath; flower head terminal, solitary, on a stout peduncle about 2 cm. long, in fruit about 3 cm. in diameter, dense; bracts bright purple, broad, glabrous; nutlets 4 mm. long, grayish, obscurely tricostate dorsally, plane on the inner surface.

Type in the U. S. National Herbarium, no. 1,153,871, collected in open thicket on hills north of Frijoles, Canal Zone, Panama, Dec. 19, 1923, by Paul C. Standley (no. 27550).

Although a single specimen in rather poor condition is at hand, it is evident that the species represented is something quite distinct from anything previously reported from Central America.

Pyschotria chagrensis Standl., sp. nov.

Densely branched shrub 1–2 m. high, the branches slender, terete, glabrous, very leafy; stipules 8–10 mm. long, triangular-ovate, long-cuspidate, thin, brown, caducous; petioles slender, 4–12 mm. long; leaf blades elliptic-obovate, 4–8.5 cm. long, 2–3 cm. wide, usually abrupt-acuminate, with acute tip, at base usually abruptly and cuneately decurrent, thin, glabrous, slightly paler beneath; flowers mostly terminal, in a few-flowered head, surrounded by thin brown glabrous bracts similar to the stipules, the flowers sessile, enclosed in large bractlets; calyx limb brown, the lobes linear; corolla white, glabrous outside, villous in the throat, the tube 4 mm. long, ampliate above, the 5 lobes spreading, less than half as long as the tube; fruit oval, 5 mm. long, multicostate, glabrous.

Type in the U. S. National Herbarium, no. 1,215,962, collected along stream in wet forest, Barro Colorado Island. Canal Zone, Panama, Jan. 17, 1924, by Paul C. Standley (no. 31373). The following specimens also belong here:

PANAMA: Chagres, *Fendler* 110. Porto Bello, *Pittier* 2433. Barro Colorado Island, *Standley* 31370. Fort Sherman, Canal Zone, *Standley* 31109.

NICARAGUA: San Juan del Norte, *Pittier* 9657.

No other American *Psychotria* known to the writer has a similar inflorescence.

Diodia denudata Standl., sp. nov.

Erect perennial herb 30–100 cm. high, branched, the branches stout, quadrangular, glabrous, the angles narrowly winged, the wings green, with smooth margins; stipular sheath puberulent, the margin bearing numerous scabrous-margined bristles 4–9 mm. long; leaves short-petiolate, the blades ovate-elliptic to narrowly elliptic, 3–5 cm. long, 1–2.5 cm. wide acute, abruptly decurrent at base, deep green above, paler beneath, scaberulous on

both surfaces; flowers sessile in dense axillary clusters about 6 mm. in diameter, the subtending leaves much reduced above or obsolete, the upper flower clusters usually about 4 mm. in diameter; calyx lobes 4, triangular, acute, 0.5 mm. long, green, scaberulous-ciliolate; corolla white, exceeding the calyx lobes; fruit subglobose, bisulcate, 1 mm. long, scaberulous, separating into 2 indehiscent cocci.

Type in the U. S. National Herbarium, no. 1,154,022, collected on wet stream bank along the Río Tapia, Province of Panama, Panama, near sea level, Dec. 24, 1923, by Paul C. Standley (no. 28123). The following specimens also belong here:

PANAMA: Río Tecumen, Province of Panama, in moist forest, *Standley* 29364. Fort Lorenzo, *Piper* 5895.

This plant is very unlike any other species known from North America, but it is related to *D. alata* Nees & Mart. of Brazil. In that the wings of the stem are wider and retrorse-aculeolate, and the calyx is 2-lobed.

Vernonia lankesteri Blake, sp. nov.

Shrubby, 2–3.3 m. high; branches stout, herbaceous, pithy, densely griseous-lanate-tomentose, glabrescent; leaves alternate; petioles slender, pubescent like the branches, 1.5–3.5 cm. long; blades obovate, 12.5–21.5 cm. long (including the decurrent base), 5–7.5 cm. wide, acuminate, at base long-acuminate and narrowly decurrent on the petiole, serrate or serrulate except toward base and apex (teeth about 1 mm. high, acutely callous-tipped, 3–8 mm. apart), papery, above deep dull green, densely and sordidly pubescent on costa and veins with short several-celled subglandular hairs, sparsely and finely so on surface, beneath paler green, griseous-subtomentose when young, glabrescent except along the veins and veinlets, on surface densely dotted with small, mostly yellow glands, penninerved, the chief lateral veins 10–15 pairs, prominulous beneath, curved-anastomosing toward margin; heads in terminal or subterminal corymbiform panicles of 4–8, very many-flowered; pedicels pubescent like the stem, 3–8.5 cm. long, thickened below the heads; disk 2 cm. high, about 2.5 cm. thick; involucre about 7-seriate, strongly graduate, 1.5–1.7 cm. high, the 5 outer series of phyllaries triangular (outermost) to oblong-oval or oblong-obovate, with indurate greenish-white bases and shorter, usually broader, spreading or loose, somewhat nervose, herbaceous tips (those of the outermost phyllaries linear or lanceolate, acutish, of the others deltoid, obtuse or rounded), scantily appressed-tomentose, the middle ones 3–5 mm. wide, the 2 inner series erect, oblong, essentially glabrous, with brownish, subscarious, obtuse to acuminate tips; corollas "Amparo purple (Ridgway)," 19 mm. long (tube 5 mm., throat cylindric, 8 mm., teeth 6 mm.), sparsely glandular; achenes (submature), blackish brown, glabrous, 5-angled, 2 mm. long; pappus yellowish white, the outer setae similar to inner but shorter, 1–2.5 mm. long, the inner about 4.2 mm. long.

COSTA RICA: La Palma, altitude 1500 meters, Nov., 1897, *C. Wercklé* 11604. In roadside undergrowth, Santa Clara de Cartago, 23 Feb., 1924, *C. H. Lankester* 712 (type no. 1,207,014, U. S. Nat. Herb.). La Hondura, Province of San José, March, 1924, *Standley* 36602.

The specimen collected by Wercklé has been identified by Dr. H. A. Gleason as *Vernonia salvinae* Hemsl., and the Costa Rican portion of the range given in the North American Flora[2] for that species is doubtless de-

[2] 33: 81. 1922.

rived from this specimen. In *V. salvinae*, as described by Hemsley and exemplified by two specimens from Chiapas now before me, the heads are only 1 to 3; the leaves are evenly strigose-pilose over the whole surface beneath; and the considerably broader phyllaries have shining, glabrous, more or less purplish brown, indurated bases, and their tips are acuminate or apiculate and (except in the innermost) short-strigose and more or less glandular.

ENTOMOLOGY.—*The wasp* Hoplisus costalis, *a hunter of tree-hoppers.* EDWARD G. REINHARD, Canisius College (Communicated by S. A. ROHWER).

About twenty nests of the solitary wasp *Hoplisus costalis* (Cress.) were found scattered among the burrows of a large colony of bee-hunting wasps, *Philanthus gibbosus*, at Woodstock, Maryland, during the summers of 1922 and 1923. The site of this community was a sandy path, loosely paved with bricks and sheltered by a long balcony.

Exteriorly, the burrow of Hoplisus is indicated by a small mound of sand, in expanse no larger than the area which could be covered by the palm of one's hand. The nest entrance is always concealed under a covering of sand. A straw probe quickly finds the hidden doorway. From thence a slanting shaft penetrates the earth for five or six inches, making a moderate dip of about 30 degrees with the horizontal surface. At a depth of two inches the gallery is terminated by a scattered group of cells, each of which is stored with sufficient food to nourish a single Hoplisus during its larval growth. Every nursling receives for its nutriment a common diet of tree-hoppers, but the communistic system does not distribute an equal share to all. Of the 34 larvae whose provisions were listed, seven enjoyed six pieces of game, nine had five, seventeen had four, and one had only three articles to satisfy its appetite.

The victims that are selected by Hoplisus for the nourishment of her grubs are all tree-hoppers, all members of the great Homopterous family Membracidae.[1] In hunting these Membracids the wasp shows no exclusive preference for any particular species, but she does seem to restrict her choice to the mature adults, as if deeming the mere undeveloped nymphs undesirable game. I have taken more than a dozen different species of tree-hoppers from the nests which Hop-

[1] G. P. Barth states of *Gorytes canaliculatus:* "The prey of the wasp seems to be exclusively leaf-hoppers of the species *Cyrtolobus fenestratus* Fitch and *Atymna inornata* Say." Cyrtolobus and Atymna however are *Membracidae*, "tree-hoppers" therefore, though the writer calls them "leaf-hoppers" throughout his account, a term which common usage has restricted to the *Jassidae*.

lisus had provisioned in this neighborhood. Among these species were: *Ceresa bubalus* Fabricius, *Ceresa borealis* Fairmaire, *Telamona monticola* Fabricius, *Telamona tristis* Fitch, *Telamona unicolor* Fitch, *Thelia bimaculata* Fabricius, *Glossonotus crataegi* Fitch, *Archasia galeata* Fabricius, *Cyrtolobus arcuatus* Emmons?, *Vanduzea arcuata* Say, *Platycotis vittata* Fabricius, *Campylenchia latipes* Say. These Membracids were kindly determined for me by Mr. W. L. McAtee.

Hoplisus is a skilful huntress, but also a skilful paralyser. The Membracids are stung to complete immobility. Once the wasp has performed her surgical operation the victim becomes as quiet as a wax model. This state of traumatic coma persists for about a week; then the victim dies.

But is the skill of the paralyser always unerring and infallible? The following fact suggests a negative answer. On August 4, I examined a burrow of Hoplisus consisting of a shaft and a single cell. In the corridor was the female wasp, and in the cell a solitary green tree-hopper, *Ceresa borealis*. Far from being paralysed to immobility the tree-hopper could thrash its legs about very vigorously, and its wings also, though it could neither walk nor fly. These strenuous muscular movements persisted through the entire day, but on the following day the victim died, supposedly from exhaustion. Here was a case where the wasp's sting had brought about mere motor ataxia instead of complete paralysis. Hoplisus had evidently bungled badly. How can we exonerate her clumsiness? The first week of August marks the appearance of the second generation, and a single cell, provisioned with a single hopper, points to the very commencement of the wasp's active career. So let us say that it was the tyro's first operation; she was as yet a novice in wielding the lancet—and such would be by no means a fictitious excuse.

Once a suitable victim is selected and properly paralysed, Hoplisus proceeds to straddle her prey, venter to venter, grasping it close to her body with her median legs, and in this attitude transports the unresisting bug through the air. Most of the wasps carrying prey succeed in landing squarely in front of their burrow, but not unfrequently one or another happens to descend wide of the mark. That is a mishap which necessitates an awkward portage along the ground. The tree-hopper's high back or projecting horns cause the wasp many a tumble and a tussle before she finally gains the nest with her burden.

When the wasp arrives at her burrow she scrapes it open and enters without releasing her prey. But once inside she usually drops

the hopper just within the vestibule, then turns around and pulls the prey down after her into the depths of the nest.

The egg of *Hoplisus costalis* is about three millimeters long; smooth, white, and bow-shaped. It is carefully tucked beneath the folded legs of the tree-hopper, along one side of its broad breast. One end is fixed to the metasternum near the hind coxa; the other arches forward towards the hopper's head.

Sometimes the wasp makes use of a curious appliance to hold her precious egg in position. On the sternum of Membracidae, alongside the middle leg, there is a projecting spur, a curved, blade-like process. It forms with the adjoining coxa a deep notch. When closed by the overlying femur this notch becomes a socket exactly fitted to receive the wasp's egg. When particularly careful the mother slips the end of her egg into this natural pocket, thus clamping it more securely in place.

It takes but two days for the egg to hatch. Five days are spent by the larva in consuming the tree-hoppers. Then the cocoon is fashioned—an oblong-ovate capsule put together with silk and sand; a neat and tough pupal casket, not without artistic merit.

The nests of this wasp are sometimes parasitized by a small Tachinid. Two cells were unearthed on August 2, provisioned with green tree-hoppers but each occupied by a Dipterous maggot. Three days later these larvae formed their coarctate kegs, but the adult flies failed to emerge. Mr. C. T. Greene, of the United States Bureau of Entomology, examined the puparia, and found that they were the pupal cases of *Pachyophthalmus signatus* Meigen. Two empty pupuria of the same species were also taken from an old Hoplisus cell in which there were the remains of four Membracids.

A bold and successful ravager of the nests of Hoplisus is her parasitic relative, the Nysson wasp, *Brachystegus hoplisivora* Rohwer. The interesting activities of this Nysson parasite will be related in a future paper.

Hoplisus costalis was described in 1872, under the generic name *Gorytes*, by Cresson from a female collected in Texas. Since the male has heretofore not been known, a brief description of it is here given. The male differs from the female in the following points: Form smaller and less robust; its color is brighter, and is of a more brilliant black and a lighter yellow than the female; the basal half of the flagellum is more darkly ferruginous beneath; the clypeus is black with a median yellow spot; several yellow markings of the female, viz., line on posterior orbits, spot on mandibles, spot on metanotum,

are not present in the male; the femora are black beneath, though all are tipped with yellow; the wings are less densely smoked along the costal margin; the anterior tarsi are without combs, and the apical abdominal tergite is rounded convexly, not flattened like that of the female.

Several specimens of both sexes bearing my label are preserved in the collections of the United States National Museum. A reared pair was presented also to the American Museum of Natural History.

SCIENTIFIC NOTES AND NEWS

J. B. EBY resigned from the U. S. Geological Survey, the end of February, to engage in petroleum engineering in Texas.

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Dr. R. B. SOSMAN, of the Geophysical Laboratory, Carnegie Institution of Washington, will give a series of lectures on geophysics at the Massachusetts Institute of Technology in March and April.

On February 7 occurred the death of WILLIAM FRANCIS HILLEBRAND, a man whose name is known wherever chemistry is taught or practised.

Dr. Hillebrand was born in Honolulu, December 12, 1853. After two years at Cornell University (1870–72) he completed his training at the Universities of Heidelberg and Strassburg and at the Mining Academy at Freiberg. Returning to America he began practise as an assayer but entered the laboratory of the U. S. Geological Survey at Denver in 1880. He was transferred to Washington in 1885 and the remaining forty years of his life were spent here. In 1908 he became chief chemist of the Bureau of Standards.

He made many important contributions to his chosen science but was best known for his work on the analysis of rocks and minerals. Dr. Hillebrand was the first chemist to make a practice of determining all of the so-called minor constituents of minerals and rocks. His painstaking work in this field provided much information of geological significance, and will undoubtedly throw light on generalizations which are still to be made. His methods for rock analysis were described in five Bulletins of the Geological Survey, the last one, Bulletin 700, appearing in 1919. These bulletins have always been in great demand. Two of them were translated and published in Germany. At the time of his death he had already spent a year in the preparation of a book on inorganic analysis. Fortunately his notes are so complete that his associate, G. E. F. Lundell, will be able to finish this work.

Dr. Hillebrand was one of the world's great chemists because of his knowledge in his chosen field and because of his absolute honesty of purpose and the high standards he set for himself. His attitude toward his work and his achievements in it inevitably brought recognition from his fellow scientists. He was President of the Washington Chemical Society in 1903 and of the American Chemical Society in 1906, at a critical time in the history of that organization. He was a member of the American Philosophical Society and of the National Academy of Sciences. In 1916 Columbia University awarded him the Chandler medal for his attainments in chemistry. He was a charter member of the ACADEMY.